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Schedule-Driven Costs in Major Defense Programs

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Government Accountability Office

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Preface & Acknowledgements

Welcome to our Ninth Annual Acquisition Research Symposium! This event is the highlight of the year for the Acquisition Research Program (ARP) here at the Naval Postgraduate School (NPS) because it showcases the findings of recently completed research projects—and that research activity has been prolific! Since the ARP's founding in 2003, over 800 original research reports have been added to the acquisition body of knowledge. We continue to add to that library, located online at www.acquisitionresearch.net, at a rate of roughly 140 reports per year. This activity has engaged researchers at over 60 universities and other institutions, greatly enhancing the diversity of thought brought to bear on the business activities of the DoD.

We generate this level of activity in three ways. First, we solicit research topics from academia and other institutions through an annual Broad Agency Announcement, sponsored by the USD(AT&L). Second, we issue an annual internal call for proposals to seek NPS faculty research supporting the interests of our program sponsors. Finally, we serve as a “broker” to market specific research topics identified by our sponsors to NPS graduate students. This three-pronged approach provides for a rich and broad diversity of scholarly rigor mixed with a good blend of practitioner experience in the field of acquisition. We are grateful to those of you who have contributed to our research program in the past and hope this symposium will spark even more participation.

We encourage you to be active participants at the symposium. Indeed, active participation has been the hallmark of previous symposia. We purposely limit attendance to 350 people to encourage just that. In addition, this forum is unique in its effort to bring scholars and practitioners together around acquisition research that is both relevant in application and rigorous in method. Seldom will you get the opportunity to interact with so many top DoD acquisition officials and acquisition researchers. We encourage dialogue both in the formal panel sessions and in the many opportunities we make available at meals, breaks, and the day-ending socials. Many of our researchers use these occasions to establish new teaming arrangements for future research work. In the words of one senior government official, “I would not miss this symposium for the world as it is the best forum I’ve found for catching up on acquisition issues and learning from the great presenters.”

We expect affordability to be a major focus at this year’s event. It is a central tenet of the DoD’s Better Buying Power initiatives, and budget projections indicate it will continue to be important as the nation works its way out of the recession. This suggests that research with a focus on affordability will be of great interest to the DoD leadership in the year to come. Whether you’re a practitioner or scholar, we invite you to participate in that research.

We gratefully acknowledge the ongoing support and leadership of our sponsors, whose foresight and vision have assured the continuing success of the ARP:

- Office of the Under Secretary of Defense (Acquisition, Technology, & Logistics)
- Director, Acquisition Career Management, ASN (RD&A)
- Program Executive Officer, SHIPS
- Commander, Naval Sea Systems Command
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- Program Executive Officer, Littoral Combat Ships

We also thank the Naval Postgraduate School Foundation and acknowledge its generous contributions in support of this symposium.

James B. Greene Jr.
Rear Admiral, U.S. Navy (Ret.)

Keith F. Snider, PhD
Associate Professor



Panel 15. Major Defense Acquisition Programs: Assessment and Challenges to Successful Management Outcomes

Thursday, May 17, 2012	
9:30 a.m. – 11:00 p.m.	<p>Chair: Dr. Nancy Spruill, Director, Acquisition Resources and Analysis, Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics</p> <p><i>A GAO Assessment of the DoD's Major Weapon Systems Acquisition Program Portfolio</i> Michael Sullivan, <i>Government Accountability Office</i></p> <p><i>Schedule-Driven Costs in Major Defense Programs</i> Roy Wood, <i>Defense Acquisition University</i></p> <p><i>Acquisition Risks in a World of Joint Capabilities: A Study of Interdependency Complexity</i> Mary Maureen Brown and Graham Owen <i>University of North Carolina at Charlotte</i></p>

Nancy Spruill—Dr. Spruill is the director of Acquisition Resources & Analysis at the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics. Dr. Spruill received her Bachelor of Science degree in mathematics in 1971. From 1971 to 1983 she held a variety of positions with the Center for Naval Analyses, including technical staff analyst, professional staff analyst and project director. She earned her Master of Arts in mathematical statistics in 1975, followed by her doctorate in 1980.

Dr. Spruill served on the staff of the Office of the Secretary of Defense from 1983 to 1993. Initially, she was the senior planning, programming, and budget analyst in the Manpower, Reserve Affairs and Logistics Secretariat. Later, she served as the director for support and liaison for the Assistant Secretary of Defense for Force Management and Personnel. Then she served as the senior operations research analyst in the Office of the Assistant Secretary of Defense for Program Analysis and Evaluation.

In March 1995, she was selected as the deputy director for acquisition resources for the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)). In February 1999, she was appointed the director of acquisition resources and analysis (ARA) for the USD(AT&L). In this capacity, she is responsible for all aspects of AT&L'S participation in the Planning, Programming and Budgeting System (PPBS); the congressional process; and the Defense Acquisition System. She serves as the executive secretary to the Defense Acquisition Board and is responsible for the timely and accurate submission to Congress of Selected Acquisition Reports and Unit Cost Reports for Major Defense Acquisition Programs. She manages the Defense Acquisition Execution Summary monthly review of programs; monitors cost and schedule status of high interest programs; and conducts analyses of contract and program cost performance including analysis of the effective use of integrated program management principles through the use of earned value management. She leads the Department in developing plans to manage property, plant and equipment, inventory, operating materials and supplies/deferred maintenance and environmental liabilities. She proposes modifications to, or acquisition of, new DoD feeder systems, in support of achieving an unqualified audit opinion on DoD financial statements as mandated by the Chief Financial Officers (CFO) Act. She also manages the studies program for the OSD, oversees the USD(AT&L)'s office automation



system and manages its information system network. She serves as the focal point for DoD-wide software-intensive systems program initiatives to improve mechanisms for the management of defense acquisition programs; manages software intensive systems assessment initiatives; performs systemic analysis from independent expert program reviews to improve acquisition policy and education, and conducts special analyses for the under secretary.

Dr. Spruill has been a member of the Senior Executive Service since 1995. She is a certified acquisition professional and an active member of the American Statistical Association. Her many honors and awards include the Defense Medal for Exceptional Civilian Service, the Defense Medal for Meritorious Civilian Service, the Hammer Award, and the Presidential Rank Award. She has contributed papers in publications of the statistics and defense analyses communities and authored articles in the general press on how politicians use—and abuse—statistics.



Schedule-Driven Costs in Major Defense Programs

Roy Wood—Dr. Wood is the dean of the Defense Systems Management College, Defense Acquisition University. A retired Navy engineering duty officer, Dr. Wood has experience in shipboard combat systems remote sensing, high energy lasers, and missile defense. He holds a BS in computer science from Texas A&M University, master's degrees in engineering and business, and a PhD in organization and management. His dissertation dealt with program manager competencies. [roy.wood@dau.mil]

Abstract

Most program managers seem focused on controlling costs and delivering a quality product. The third leg of the acquisition stool—program schedule—is perceived to be less important and seems to be a resource that can be slipped to accommodate unstable funding or technical difficulties when they are encountered. Given that most major defense program schedules span years or even decades, schedule slips are less likely given their importance. This paper reviews the extant literature on cost and schedule relationships and examines the reasons that schedules may be problematic to acquisition success. Synthesis of previous findings, together with results of an exploratory survey of program management course students at the Defense Acquisition University, provide the basis for several propositions for further study that may improve acquisition outcomes.

Introduction

This paper explores the relationship between program cost and schedule. The literature is inconsistent and seemingly contradictory in many of the conclusions about the impact that schedule can have on cost and program performance. While most of us have heard the supposed truism that “time is money,” there has been little evidence that schedule has been a focus of program managers’ attempts to control costs. As an exploratory effort, this research examined the literature on program scheduling and the relationship of program schedules to cost and program performance. Using an informal survey of 71 program managers attending 400-level courses at the Defense Systems Management College, the paper also examines program manager attitudes toward their own program schedules. The paper synthesizes this material and provides several propositions for further research.

Time Is Money

Program success is traditionally measured by cost, schedule, and performance. When issues arise, trade-offs between these three are made, and conventional wisdom says you can generally preserve only two of the three. For example, if current budgets are cut, then programs are forced either to give up some bells and whistles in performance or to lower the spend rate and stretch out the program schedule. If the program schedule is delayed for reasons such as lagging technology readiness or testing failures, then program costs will rise or content will have to be sacrificed.

When making such trade-offs, there are reasonably good tools and techniques for estimating the cost impacts, and performance trades are similarly understandable. However, when it comes to program schedules, trade-offs can be much less clear and the impacts more difficult to determine. Working harder or placing more management emphasis on problem areas are often believed to be practical ways to improve performance and compress schedules to remain on track. Too often, however, these ideas can lead to the attitudes that time, unlike money, is somehow more elastic and forgiving. This also leads to misapprehensions about the diminished value of program time in the future versus the amplified importance that urgency brings regarding current schedule issues. At times, managers feel that resource problems occurring in the near term can be “fixed” by pushing problems into the future. This can result in moving milestones forward while keeping the



program end date static and compressing the activities in between. This forces activities to become more concurrent, increasing the need to more closely synchronize tasks and the increasing the complexity of synchronizing program activities.

Creating Program Schedules

In an ideal situation, program schedules are developed in a rational and linear manner. Program requirements are analyzed and developed through the iterative system engineering process, allocating required functions to be performed by the system's hardware, software, and operators. Work breakdown structures (WBS) are created, assigning those functions to subsystems and components. At the lowest level of the WBS, work packages are developed that estimate the resources—dollars, time, and manpower/expertise—required to build, test, and deliver the hardware and software widgets. Rolling up the task-level resource requirements to higher levels of the WBS, then, allows the program manager to create a total program budget estimate, resource-loaded schedule, and program manpower estimate. This integrated master schedule will show each task with its estimated duration, required human and physical resources, linkage to other tasks to show dependencies (e.g., Task B cannot start until Task A is complete), major milestones where tasks culminate in a defining program event, and the calculated program end date and critical path. If each task is then given the appropriate resources and is managed in order to be completed within its estimated time frame, then the program execution proceeds from start to finish with nary a problem.

Unfortunately, this is generally not how program schedules are arrived at. Project end dates are more often arrived at starting with a “need date” established early in the program by the user or sponsor, without regard to program details or complexity. In the survey of program management students at the Defense Systems Management College (DSMC) in 2011, only 18% reported that their program end date was determined through a roll-up of task level schedules, while 58% reported end dates that were predetermined by need.

Herein appears to lay the source of some inherent program problems. In this method of program end date determination, the end date is fixed and the program milestones are “backed out” from there. Other project tasks are fitted into the milestone scheme, along with whatever concurrency and optimism are needed to make the schedule work. Fully 82% of the program management students participating in the DSMC survey reported that their program schedules contained some or significant concurrency with moderate to high schedule risk.

In execution, these programs must accept risks to stay on schedule. The Government Accountability Office (GAO) has noted repeatedly in its annual *Assessments of Selected Weapons Programs* that projects proceed through milestones without reaching the requisite knowledge points (GAO, 2009, 2010, 2011). This results in many programs being “at a higher risk for cost growth and schedule delays” (GAO, 2011, p. 2).

Project Concurrency

The reasons most often cited for foreshortened schedules and concurrency are outlined in the following sections.

To Meet an Urgent Need for a Product

Mine resistant ambush protected (MRAP) vehicles were a contemporary case in which there was an urgent battlefield need for vehicles that could protect soldiers from improvised explosive devices (IED). The original program schedule for a limited number of the vehicles was vastly expanded to maximize the number of vehicles in theater in a short



period of time. There was concurrency within and across vehicle types and contractors. It was a Herculean effort reminiscent of the ramp-up in World War II in the rapid mobilization of the industrial base to provide the number of needed vehicles for the war.

On the other hand, programs are too often assigned unrealistic need dates and have little to no chance to deliver the programs on time. For example, the F-22 Raptor program was begun in 1981 as the Advanced Tactical Fighter (ATF) program, with an initial operating capability need date of 1993. The actual capability was delivered 12 years late, in December 2005. Likewise, the Navy's Surface Combatant, 21st Century, or SC-21, was envisioned to be delivered in fiscal year 2008. Ultimately, the ship class was renamed the DDG-1000, the first of which has not yet been delivered to the fleet. Both programs experienced severe technical challenges and cost overruns that contributed to severely restricting the numbers of aircraft and ships originally required.

To Avoid Obsolescence

Evolutionary acquisition is a paradigm in which a design is frozen at a point in time and the system goes to production as-is. Later, new technologies and capabilities may be added incrementally to the design and later systems may be produced with those upgrades. While this process limits the "churn" and allows stable baselines to be designed and produced, it requires some concurrency in design and integration as each new block is started. These new designs commence before the previous baseline system has been fully built, tested, and employed in the field. This creates the possibility of design rework.

To Maintain the Industrial Base

Defense companies must maintain a relatively steady flow of work to keep their engineers, designers, and manufacturing personnel employed and maintain their competitive expertise. This means that, for example, as one submarine transitions from design to production, another new submarine requirement should ideally be coming in the door to keep the designers employed. Otherwise, these talented individuals might leave the companies, making reconstituting submarine design in the future very challenging. While this process is perhaps inefficient from the government's perspective, it is necessary to prevent losing vital national defense skills.

Drivers of Schedule Slippage

Performance challenges can create schedule slippage in a variety of ways.

Technology "Reach"

It is not uncommon for large, complex defense programs to rely on relatively immature technologies that require significant in-line development. The need to meet a supposed future threat drives an appetite among users toward ever greater technical capabilities, many of which are immature (or even nonexistent). For example, stressing requirements for the Air Force F-22 Raptor included stealthy titanium and composite structures, advanced avionics, active-array radar, supersonic cruise, and dozens more enabling technologies (Copp, 2007). Similarly, the Navy's Zumwalt-class destroyer included requirements for reduced crew size, integrated dual-band active-array radar, integrated power system, electric drive, stealthy tumblehome hullform, integrated superstructure, 155 mm advanced gun, and peripheral vertical launching system (Galdorisi & Truver, 2010, p. 66). Many of these advanced technologies in both programs were co-developed and matured during the engineering and manufacturing development phases (Francis, 2005; GAO, 1998).

Schedule and cost uncertainty are high for any new technology development, but this uncertainty becomes a substantial risk when overlaid on program milestones that depend



upon success and delivery of the technology to support testing and fielding a new system. When there are several new technology developments ongoing, as in the case of the F-22 and the Zumwalt destroyer, this uncertainty multiplies and orchestration of technology insertion becomes extremely challenging. It should be little surprise, then, that both of these programs delivered substantially late and over budget (O'Rourke, 2012; Bolkcom, 2009).

Insertion Time and Rework

Requirements changes during a program's lifetime can also have a substantial impact on schedule and cost. In a recent Center for Strategic and International Studies (CSIS) analysis, \$37 billion of cost overruns in the major defense acquisition program portfolio are attributed to schedule, and the CSIS report notes that defense contractors cite requirements changes late in a program as a major cause of schedule impacts (Berteau, Hofbauer, Sanders, & Ben-Ari, 2010).

A recent industry white paper stated that "frequent and 'inside lead time' changes to program requirements and production schedules are major obstacles to successful cost and schedule attainment for most aerospace and defense programs" (Archstone Consulting, 2012). This assertion is backed by the 2008 GAO analysis of defense weapons systems that stated that "sixty-three percent of the programs we received data from had requirements changes after system development began. These programs encountered cost increases of 72 percent, while costs grew by 11 percent among those programs that did not change requirements" (p. 5).

When requirements changes occur during development, replanning and rework follow. New requirements must be flow down as allocated functions via the system engineering process. Now, however, the new requirements must be integrated as well as possible into existing program plans. This adds complexity and takes time and care to avoid unintended downstream conflicts and consequences. Requirements changes drive drawing and specification revisions, modification of schedules and task budgets, and reallocation of resources to attend to new or modified tasks. In almost any conceivable circumstance, prior wasted effort will be scrapped and rework will be required to accommodate new changes, exacerbating the delay and disruption created by the new requirements.

Unstable Budgets

Unstable funding has often been blamed for program schedule and cost issues. Langbein (2004) cites three different types of funding instability that impact programs. The first is perhaps the most obvious—quantity of dollars. These are programs with insufficient total funding to perform the required tasks to deliver the system. This problem can be caused by poor cost estimating for the funding that is needed by the program, unforeseen and unbudgeted changes, or overly optimistic cost targets. In defense acquisition, there are two other less obvious funding pitfalls in *colors of money* and *timing of money* that can create program instability and schedule problems.

Colors of Money

In every program, defense program managers must break down total funding into its constituent functions and categories, known as different colors of money, for specific portions of the program. Research and development, procurement, operations and maintenance, shipbuilding and conversion, and other colors of money must be appropriately aligned to fund the associated tasks in the program. At times, a program may have sufficient overall funding but an incorrect allocation within the colors of money. The program manager may find that there are shortfalls in some areas and surpluses in others but not have the authority to move the congressionally appropriated dollars from one account to another. These shortfalls can stop activities in parts of the program and create overall delays.



Timing of Funding

Timing of funding can also create similar problems. Program budgets are closely aligned with planned work in any given year. If challenges or opportunities arise within the year of execution, current year funding may not be sufficient to accommodate new funding requirements, again creating potential delay and disruption to the program schedule.

In each of these cases, program schedules must be replanned to accommodate different funding realities. Reprogramming or repurposing current-year funding is generally not simple or quick. Requests for more, or different, funding can take up to two years to realize through the Planning, Programming, Budgeting, and Execution (PPBE) system. The alternative to reprogramming may be that tasks must be trimmed in the current year and work adjusted so the financial impacts can be addressed over the longer term. When these things happen, key events and milestones are missed, concurrency increases, and opportunities are lost.

“Marching Army”

Whether from requirements changes, funding instability, or other causes, any schedule delays create disruption to well-planned and ongoing activities. In many cases, while waiting for problems to be resolved, the government and contractor workforce remains in place but their contributions to the program are less than optimal. Nevertheless, this less productive workforce continues charging to the program, driving up costs. Simply disbanding the program team for temporary delays is generally not practical. Moving highly specialized individuals with experience and intimate knowledge of their assigned program to other programs or tasks, with an eye to reassemble them later after the causes of the delays are determined and fixed, does not usually make sense. Reconstituting the team would create more churn—and cost—both in the delayed program as well as in the new projects to which they were temporarily assigned. This “marching army” cost, then, may be considered a fixed cost that must be paid regardless of the productivity impacts caused by delays. When programs are disrupted, these costs continue largely unabated, adding to total program cost whether or not the labor is contributing substantially to program completion. The longer the delay continues, the more these unproductive costs build. Time is money.

Schedule Optimism

Given that many program end dates are set well before any of the work begins, perceived necessity, concurrency, and optimism drive milestone schedules and tasks. Once the analysis of the work that must be accomplished is underway, there is tremendous pressure to keep to original agreements and promises to deliver, however unrealistic these turn out to be. In the “Conspiracy of Optimism” white paper, the International Centre for Complex Project Management (ICCPM) authors explain,

once initial project budgets and schedules are set, based on such estimates, they have immense staying power, driven by collective unrealistic expectations, even to the extent that over time, system functionality and project resources are sacrificed in order to achieve what was unobtainable in the first place. (p. 14)

Longer Programs Cost More...For Many Not-So-Obvious Reasons

The Packard Commission noted in 1986 that “an unreasonably long acquisition cycle ... is a central problem from which most other acquisition problems stem” (p. 8). Echoing this sentiment 20 years later, a Defense Acquisition Performance Assessment (DAPA) report recommended that, instead of waiting decades for 100% performance, programs be held to a *time certain development* period of six years from Milestone A to delivery of a militarily



useful capability (Kadish, 2006, p. 12). The report enumerated some of the benefits of shorter development cycles. Operators with a basic capability in hand would gain a better understanding of full requirements to be inserted in future baselines. Technology in the initial design would be at a higher readiness level, and technologies would mature during the period between first deliveries and subsequent upgrades, making it easier to develop to full capability over time. New requirements and technologies would be intentionally inserted in later baselines, removing the temptation to perturb the current development and adding stability to the acquisition. Reducing time in development would also help add funding stability across the entire program portfolio (Kadish, 2006, pp. 12–13).

Coleman, Summerville, and Dameron (2003) examined the relationship between cost and schedule using RAND's Selected Acquisition Report (SAR) cost growth database. Analyzing 59 programs in EMD phase, these researchers found *no* statistical correlation between cost and schedule length. However, in a dissertation study of 154 defense projects at the Massachusetts Institute of Technology (MIT), McNutt (1998) found that cost increased on a 4th power scale with development time. Figure 1 is McNutt's "best fit" curve on a logarithmic scale. Figure 2 shows the power relationship on a linear plot for emphasis and clarity. One can observe that the "knee in the curve," where costs begin to escalate significantly, is around 6.5 years, indicating that costs for programs with schedules that extend beyond this point risk quickly becoming unaffordable.

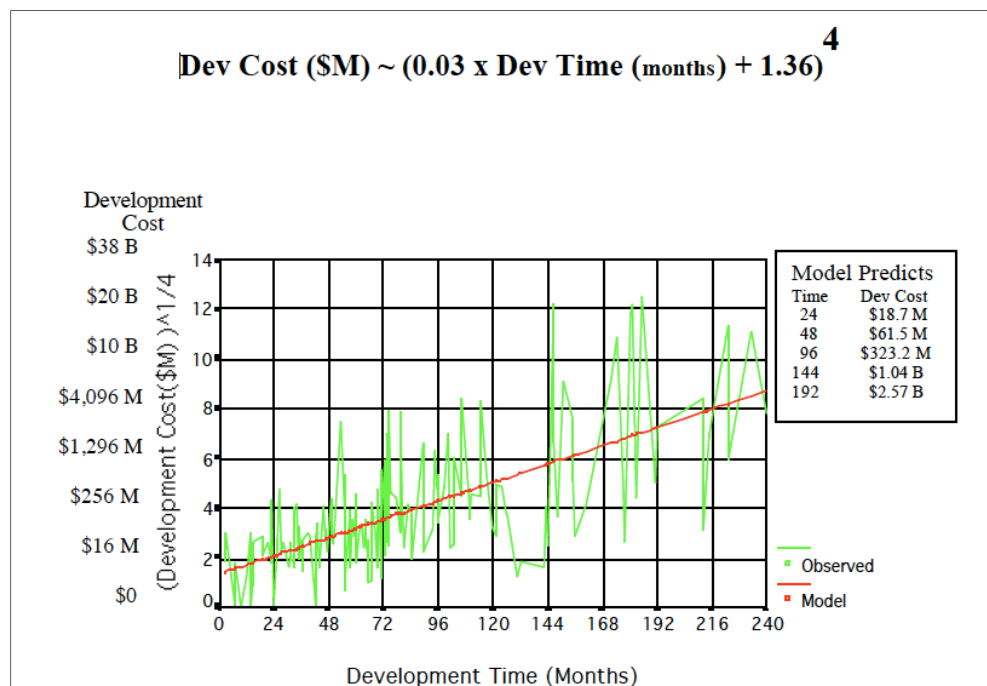


Figure 1. Development Cost vs. Development Time
(McNutt, 1998)

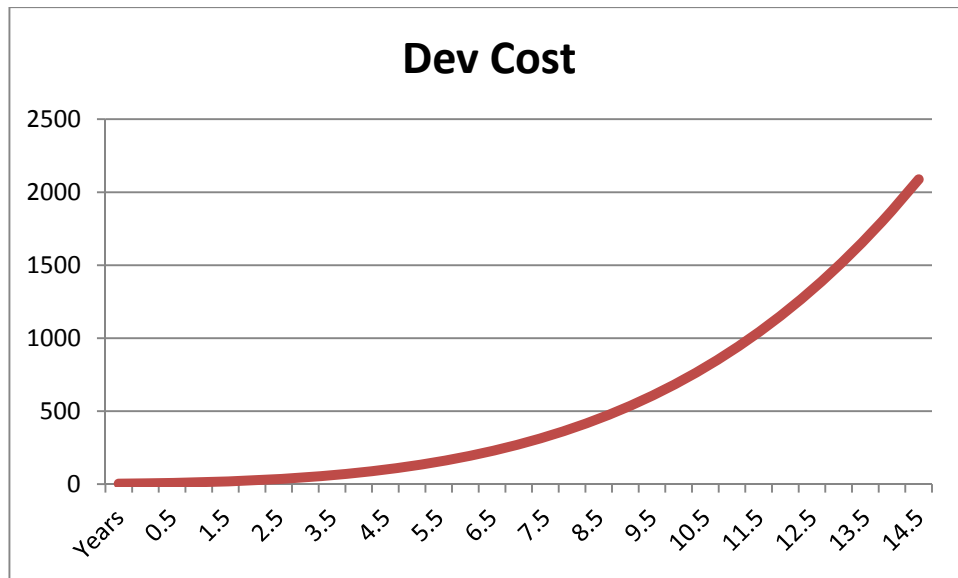


Figure 2. Development Cost vs. Time on Linear Scale

Note. Cost is shown in millions of dollars, and time is shown in years.

There are reasons that may explain why the length of a program impacts its cost so dramatically. First, longer schedules from inception may be an acknowledgement of their developmental complexity. Programs with substantial capability needs, advanced technology, unique features, or with significant integration or interdependencies with other programs can be expected from the outset to take longer to develop and/or have greater schedule risk and cost.

Programs with long time lines may also be subject to more requirements changes as threats and technologies evolve over time. As new threats emerge during a program's development, there would be pressure to try to address those threats by adding or refining the delivered system's capabilities. Likewise, emergent technologies could offer greater capability if developed and incorporated into the system's design. The added benefit of newer, more modern and capable technologies would also be a tempting reason to modify the program's plan. Just as important, over a long development period original program technologies may become obsolete before the system can be delivered, requiring that new technology be incorporated. All these changes, as noted earlier, must be replanned, often requiring scrap and rework and increased time and cost to deliver.

Long programs also potentially suffer from greater budgetary churn. Each new fiscal year presents an opportunity for decision-makers outside the program to make funding adjustments that perturb the program's overall performance. Longer programs must survive more fiscal-year budget challenges and more annual opportunities for budgetary uncertainty and strife. Likewise, longer programs with large budgets can be tempting targets for harvesting funds to help other programs get well. This can happen at any level in the organization, from the program executive officer through the defense comptrollers and/or Congress.

Proposition 1a. Longer-duration programs are subject to greater increases in cost and schedule.

Proposition 1b. Program length and cost are related in a non-linear way.



Program Managers Trust and Use Their Integrated Master Schedules—Sort of...

The process of scheduling itself is difficult and may not always be as useful as it could be as a key project management tool. The National Defense Industrial Association's Industrial Committee for Project Management (NDIA IACP) recognized that the art of scheduling for complex projects was problematic for government programs and recently chartered the Program Planning and Scheduling Subcommittee to create the *Planning and Scheduling Excellence Guide (PASEG)* (NDIA, 2011). This guide was designed to assist government and industry to create more useful, consistent, and standardized integrated master schedules (IMS) using the principles of the Generally Accepted Scheduling Practices (GASP). The guide emphasizes practical skills and application of sound scheduling principles to create a schedule that models the acquisition plan, provides tips for schedule maintenance and advice for project managers to use the IMS more appropriately to manage a complex government program.

The survey of program managers at the Defense Systems Management College revealed some insights into how schedules are viewed by current managers. Of those polled, 96% believe that having an integrated and up-to-date schedule is critical to running their programs, and two-thirds say they have confidence in the accuracy of their master schedules. However, less than half believe that their schedule is accurately resource loaded and 51% believe that their schedule includes all work required by government and contractors. These results seem to be inconsistent and perhaps contradictory: only half believe their schedules to be complete and accurate, yet most have confidence in the schedule and overwhelmingly believe that it is important to their program's success! Table 1 summarizes these views.

Table 1. Program Manager Views of Their Schedules

Statement	Agree or Strongly Agree	Neutral, Disagree, or Strongly Disagree
Having an integrated and up-to-date schedule is critical to running my program.	96%	4%
I have confidence in the accuracy of my master schedule.	65%	35%
My schedule is accurately resource-loaded.	45%	55%
My program schedule is realistic and achievable	56%	44%
My schedule includes all required work, including that of government organizations, all contractors, and subcontractors.	51%	49%

Similarly, in execution, 56% believe that their schedules are realistic and achievable, while 40% report that their programs are behind schedule. When faced with hypothetical budget cuts, 48% of the managers indicated that they would defer requirements or capabilities, while only 20% would slip schedule as a preferred method to manage overruns. However, the program managers assigned the highest priority for their programs as ensuring quality and performance of their products, and they ranked controlling program scope last in relative priority. Again, while their responses to questions of importance align closely with current policies of adjusting scope to budget, the practical priorities that PMs place on performance and scope would seem contradictory.



Finally, when posed with the statement, “Maintaining an accurate detailed schedule is too labor-intensive and costly for the value,” fewer than 10% agreed or strongly agreed. However, when asked about current program issues, respondents reported difficulty in synchronizing schedules among players as an issue second only to unstable funding. Again, this seems to indicate the importance that PMs place on the theoretical value of their integrated master schedules and an implicit recognition that large program scheduling is challenging.

Proposition 2a. Program managers who understand and use their project schedules as a management tool are more likely to be successful.

Proposition 2b. Project managers’ stated opinions and beliefs about the importance and control of program schedules are at odds with actual behavior in managing those schedules.

Conspiracy of Optimism: Overestimating Abilities While Underestimating Effort

An earlier section of this paper discussed the problems created when program teams and stakeholders underestimate the challenges and overestimate their abilities to deliver on success-oriented, aggressive schedules. This optimistic thinking necessarily flows down from the government to the system contractors. Once the government team has fallen into its own overly-optimistic decision trap, contract requests for proposal are written based on the ill-conceived plan and contractors come to the table hoping to have the most attractive bid to meet the government’s expectations. Unfortunately, this also often creates an environment where realistic assessments of cost and schedule are undervalued and contractors who refuse to join in on the conspiracy risk losing the job.

It is common for commercial considerations to lead to “doctoring” of the estimate in order to drive estimated costs down—particularly where there are strategic reasons for wanting to win that particular bid. Later, at the planning stage, this “doctoring” is forgotten and unrealistic plans are made. As the project unfolds, this lack of realism is very likely to play one of the most significant and unattributed roles in increased costs. Underestimating at the planning stage is one of the most common triggers for cost escalation. (Eden, Ackermann, & Williams, 2005, p. 19)

Kahneman (2011) argued that the optimism bias is inherent and pervasive in individuals and teams taking risks under conditions of uncertainty or ambiguity. He offered that remedies to this bias are often gained by comparing time lines for similar prior projects as a baseline for the current one, or getting an outside view from a third party who may be able to assess the reasonableness of project estimates. He also encouraged the practice of *pre-mortems*, where the project team envisions future project failure and offers all the things that might have caused it (Kahneman, 2011, p. 264). This exercise may empower the team to bring to light issues that have not been previously considered (or ignored), help break overly optimistic groupthink, and encourage the team to accept evidence of over-optimism in the project’s planning.

Proposition 3. Program plans that are subjected to objective oversight that considers historical data and trends to assess the realism of the program schedule and cost can reduce over-optimism and improve contract outcomes.

Difficulty of Obtaining Data Blurs Visibility Into Challenges and Opportunities

McNutt (1998) reported that analysis of schedule duration and schedule slips was difficult because of the lack of data. This author found that the situation has not improved



significantly in the intervening 14 years. The best public information on defense program cost and schedules remains the SARs, which are accessible to defense employees through the Defense Acquisition Management Information Retrieval (DAMIR) database. However, schedule data cannot be easily retrieved or manipulated, making analysis difficult.

In 1996, RAND provided an important data set on several hundred defense programs, relying largely on the SAR data (Jarvaise, Drezner, & Norton, 1996). This database appears frequently as a source for analytical work in the earlier literature but has not been maintained or updated with more recent data. There appears to be no current or ongoing efforts to create or maintain program information that facilitates straightforward research on base trends or analyses. Future research would benefit greatly from the identification, compilation, and maintenance of robust and public data in a consistent, clean program cost and schedule database.

Proposition 4a. Researchers would benefit from better quality and more accessible program data on cost, schedule, and performance to allow them to examine relationships and trends in program performance.

Proposition 4b. Program managers and defense decision-makers would make better-informed choices and trade-offs given better-quality research on program trends and relationships.

Future Research

In the future, each of the propositions enumerated in this paper should be examined more closely, particularly in light of conflicting research and counterintuitive results in many studies in the literature. To facilitate this, the Department of Defense should make a concerted effort to compile a useful and useable database of cost and schedule data, similar to the 1996 RAND data set. Researchers could then perform more consistent, in-depth analysis of program data, looking for causal relationships and trends that may point toward systemic problems and root causes of cost and schedule growth. Additional policy research seems to be called for to examine oversight of programs to ensure that subtle behavioral forces and biases, like over-optimism, are eliminated or minimized when creating program cost and schedule estimates. Finally, there is a need for research into how project managers and other decision-makers use schedule data with an aim to ultimately create better tools and techniques to make reviewing and manipulating schedules simpler and more easily understandable.

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Appendix: Demographics of Survey Participants

An informal survey was taken of two classes of senior program managers (PMs) at the Defense Systems Management College to get their views on program cost, schedule, and performance relationships. The survey was particularly focused on PM views of their schedules and scheduling processes. Table 2 shows the demographics of the survey participants.



Table 2. Demographics of Survey Participants

	Total
1. What is your current position	
PEO/DPEO	5
Government PM/DPM	54
APM/Program Functional Leader	3
Government Other	5
Contractor, PM/DPM	1
Contractor, Other	3
	71
2. The Program I am managing is a	
Weapons System Program	48
IT/AIS/BS	9
Procurement of Services	5
Other	10
	72
3. The program I am managing is in the:	
Research & Development	5
Technology & Development	8
Engineering & Manufacturing Development Phase	15
Production & Deployment Phase	32
Operations & Support Phase	15
Other	8
Don't Know	0
All Phases of ACQ	5
	88
4. The program I am managing is an:	
ACAT1	36
ACAT2	15
ACAT 3 or 4	20
Portfolio	5
non-ACAT	7
	83

Note. Totals exceed number of respondents who were responsible for multiple programs.





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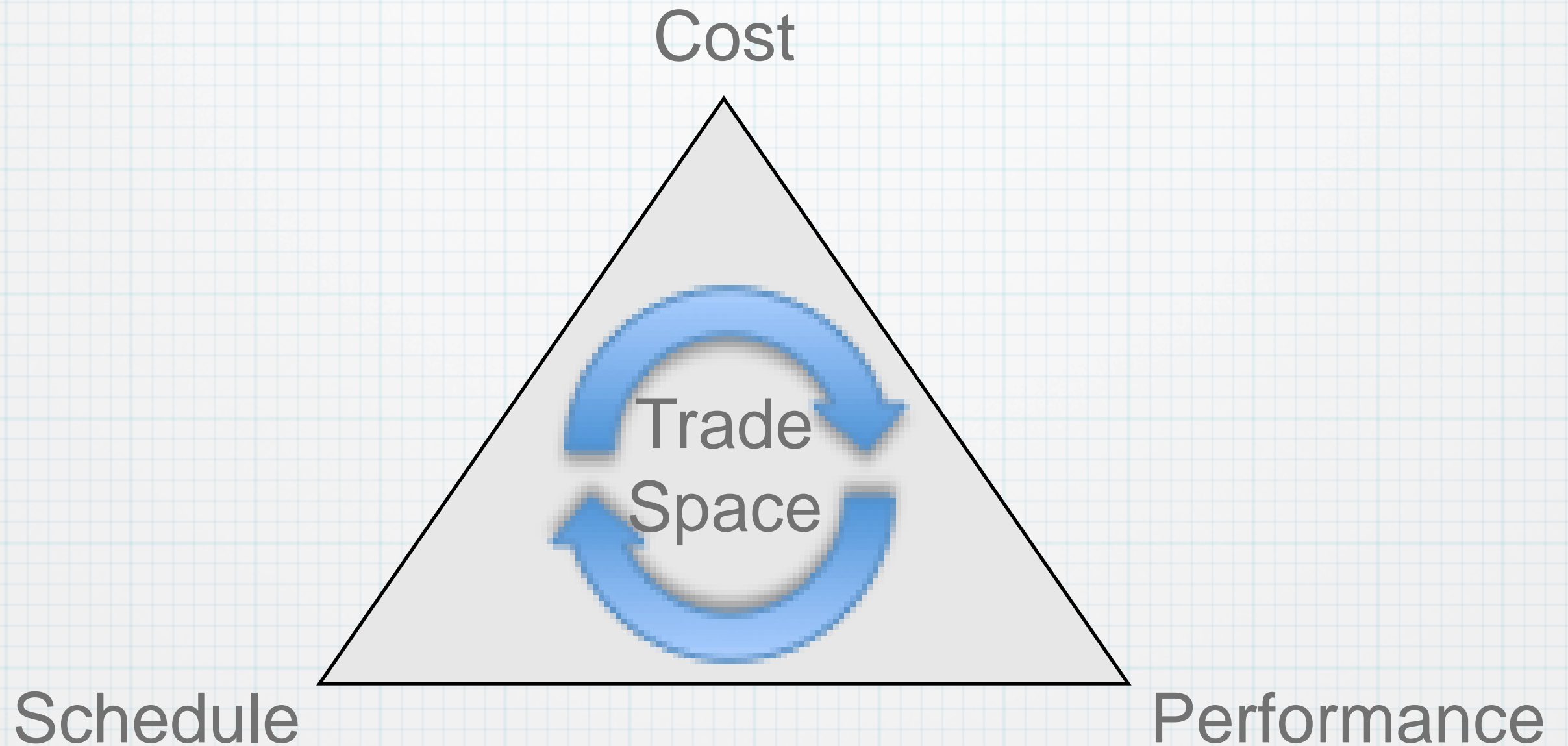
www.acquisitionresearch.net

Schedule-Driven Costs in Major Defense Programs

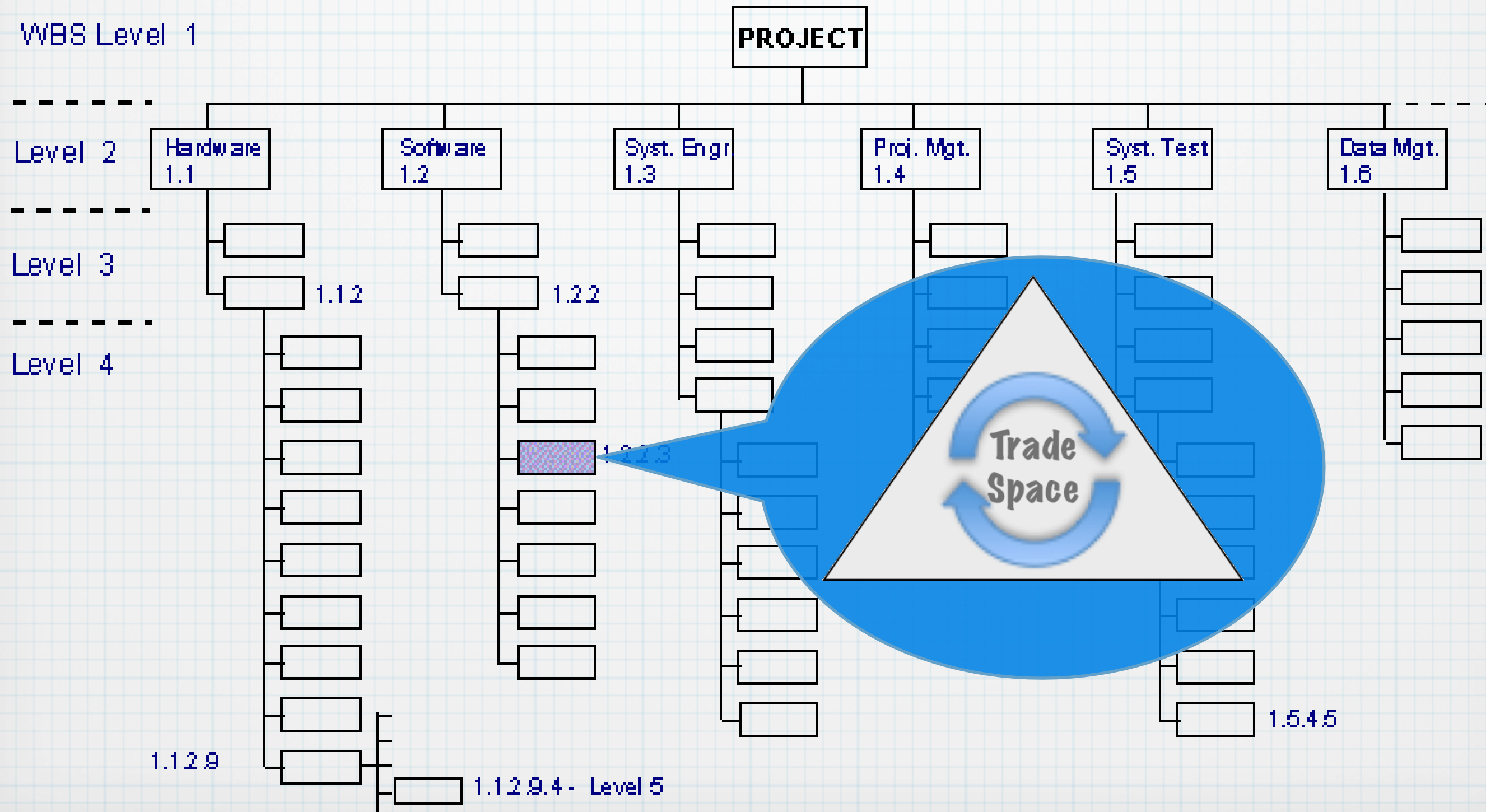
An exploratory Study

Dr. Roy Wood
Defense Acquisition University

Program Management

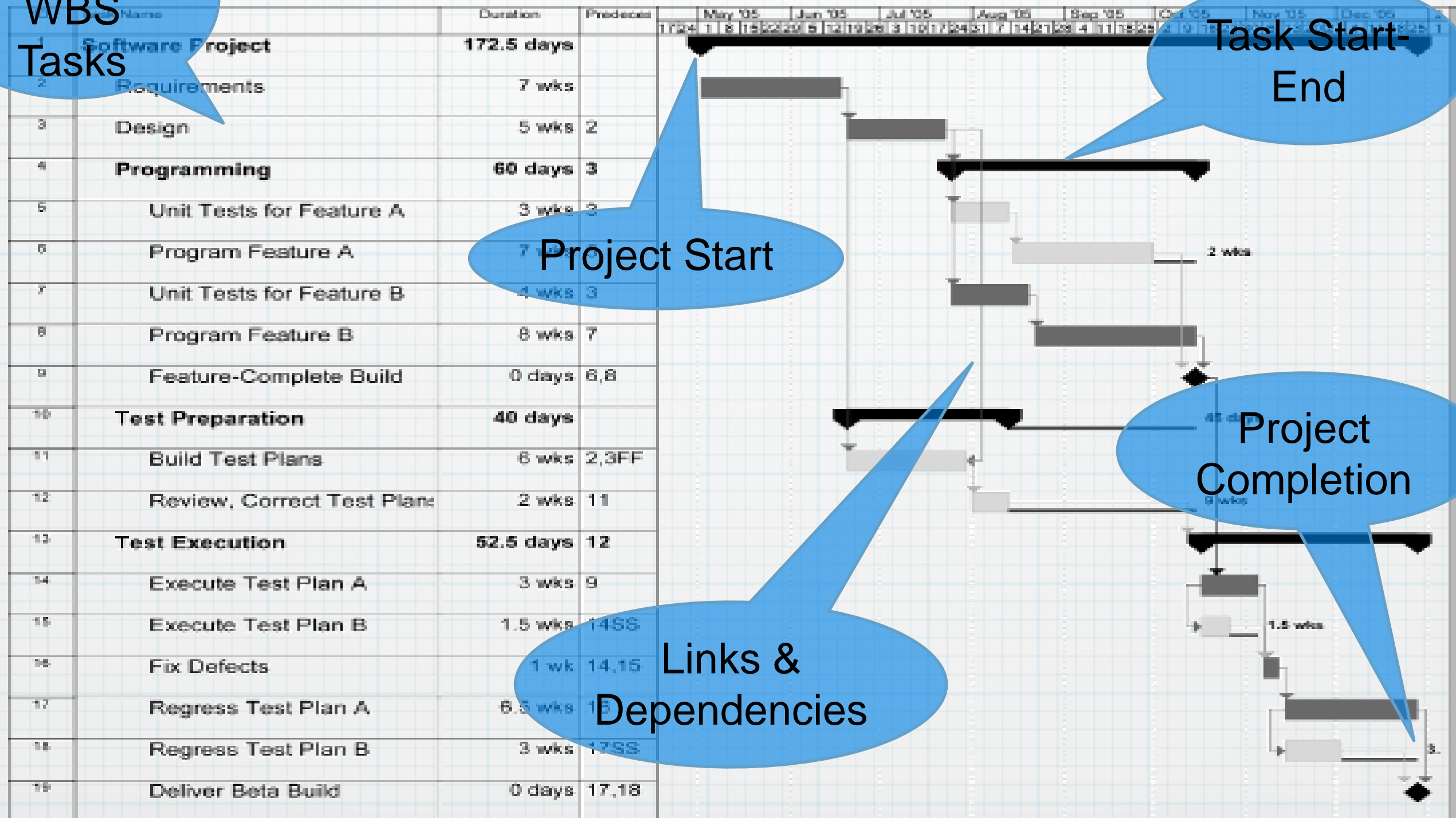


Program Work Breakdown Structure

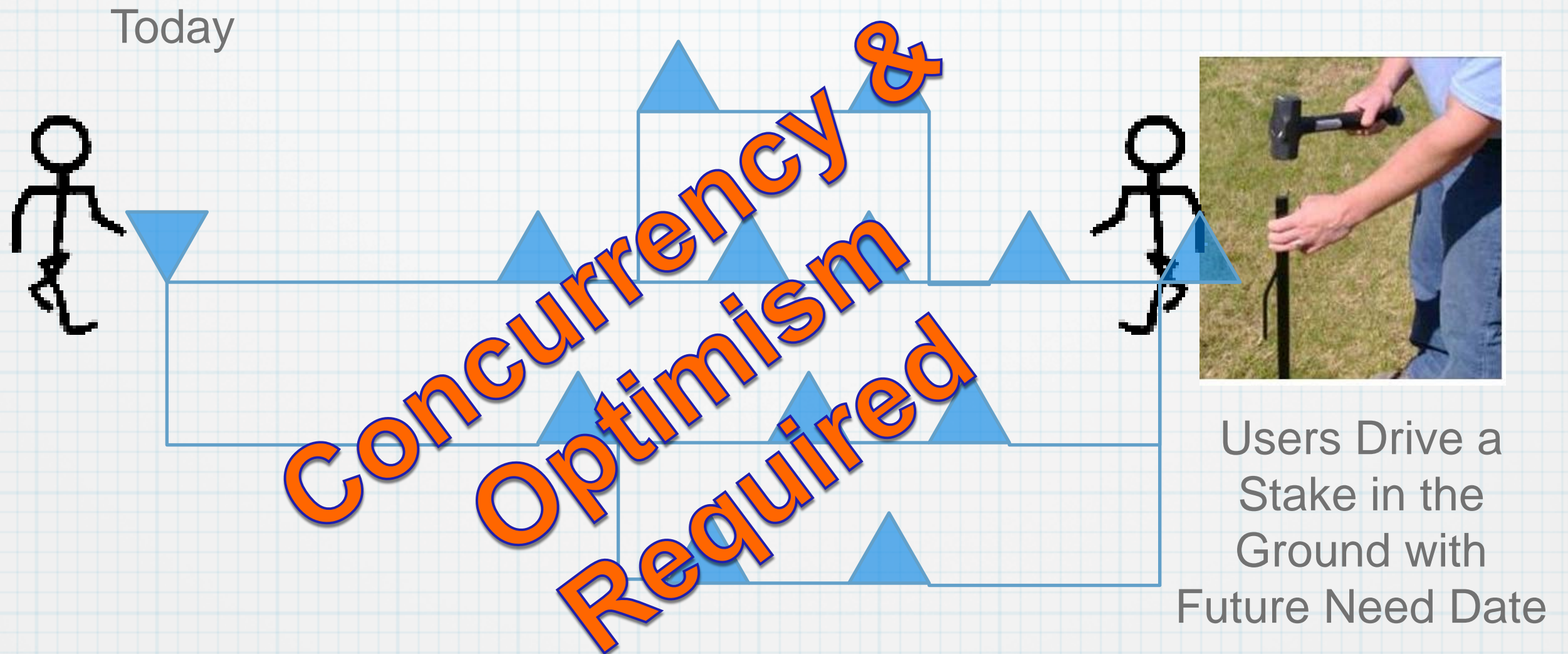


Program Schedule

Project
WBS
Tasks

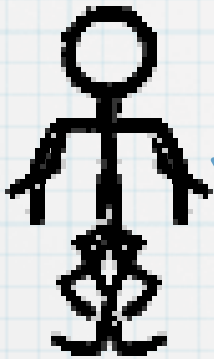


Need-Driven Schedule



Schedule Compression

Today



Compression

Today

Even More Concurrency
& Optimism Required



Users Drive a Stake in the Ground with Future Need Date

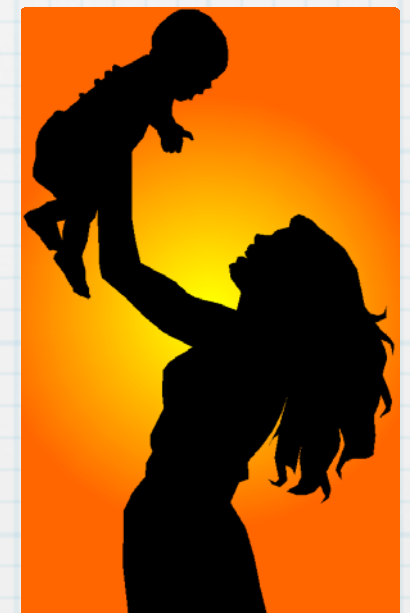
Concurrency



+ 9 Months =



+ 1 Month =



Overoptimism?

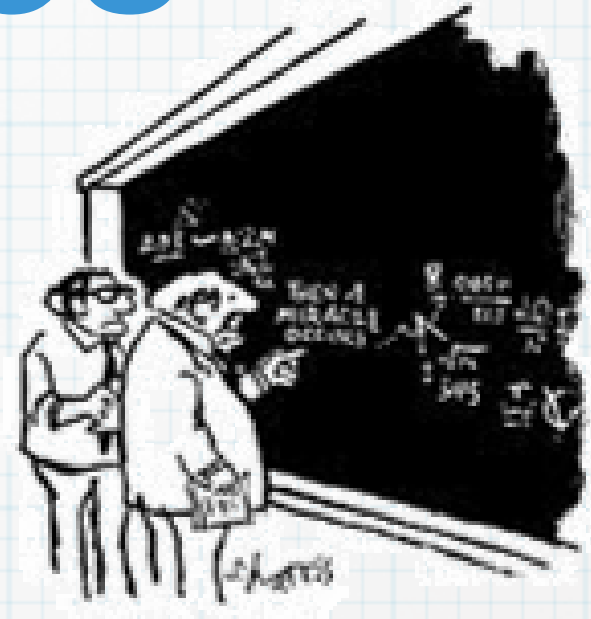
- Kahneman argues optimism bias leads to overestimation of utility, underestimation of difficulty
- How much impacts defense program schedules?
- Can the “outside view” of objective oversight counteract overoptimism?

Schedule-Cost Challenges



Technology Reach

- TRL, MRL, IRL



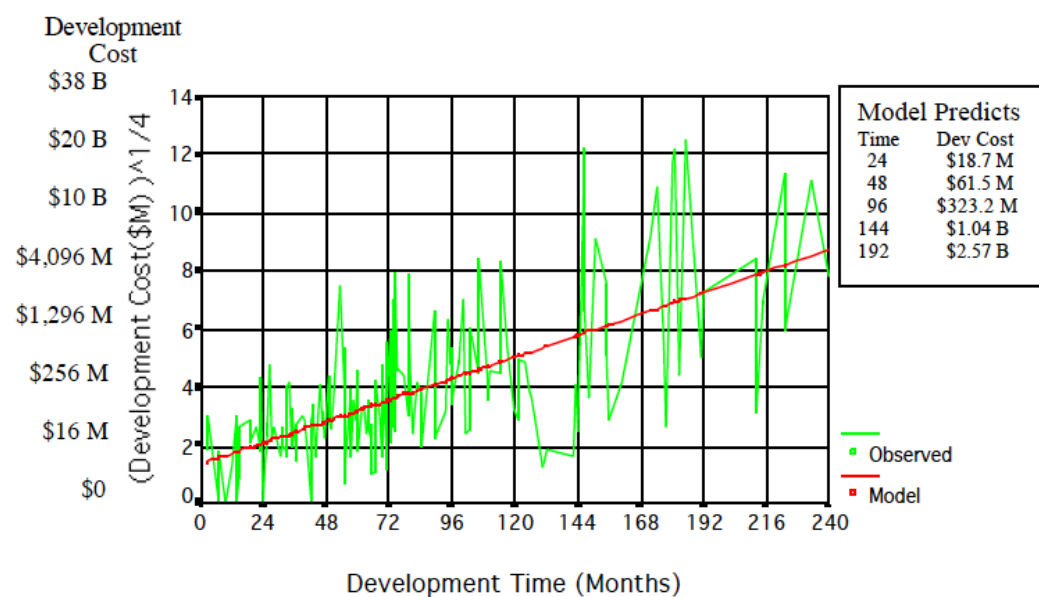
Unstable Budgets



Requirements Changes –
“It needs a turret...”

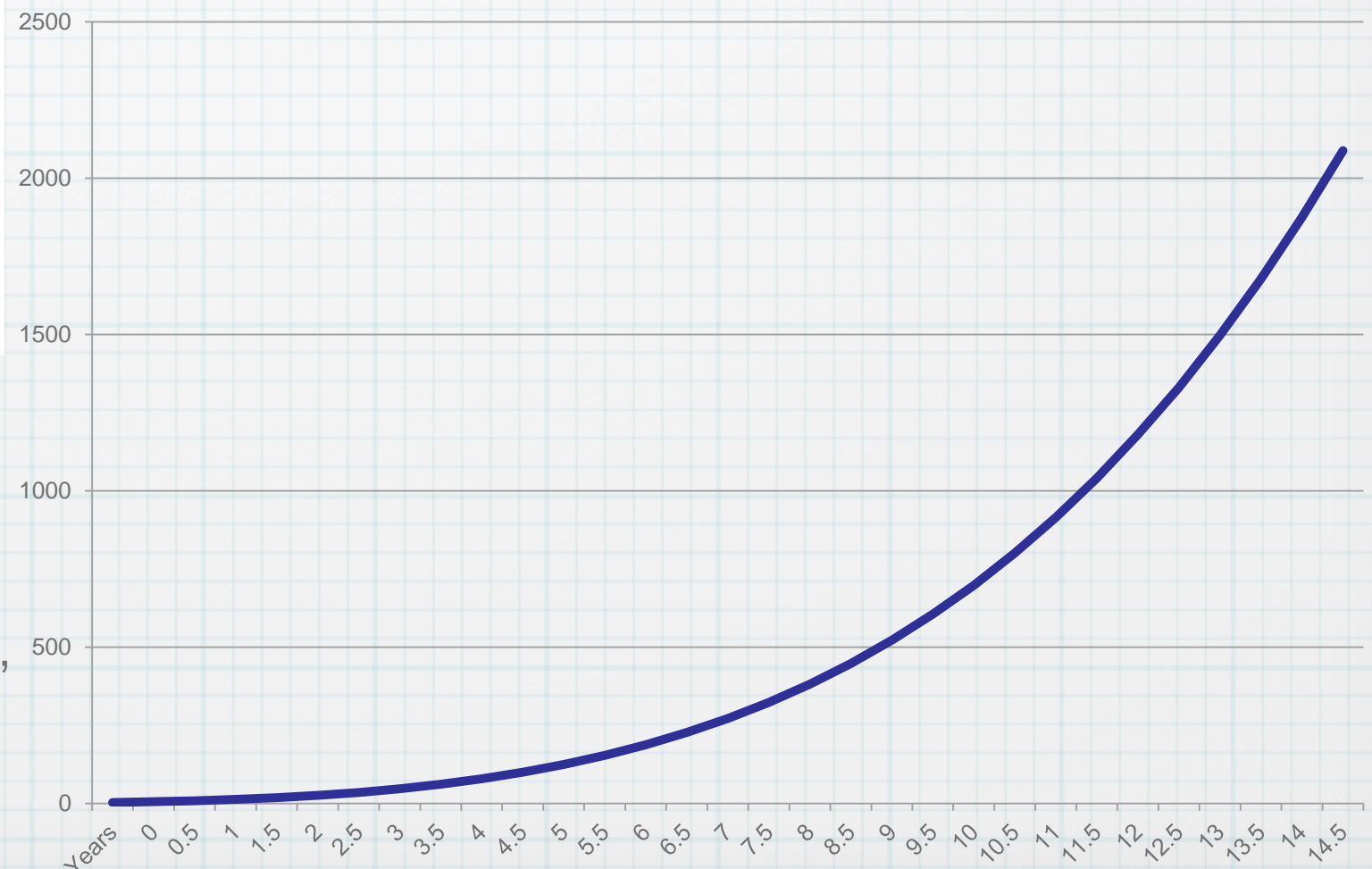
Longer Programs Cost More?

$$\text{Dev Cost (\$M)} \sim (0.03 \times \text{Dev Time (months)} + 1.36)^4$$



McNutt, R. (1998). *Reducing DoD product development time: The role of the schedule development process*. Doctor of Philosophy Dissertation, Massachusetts Institute of Technology, Boston.

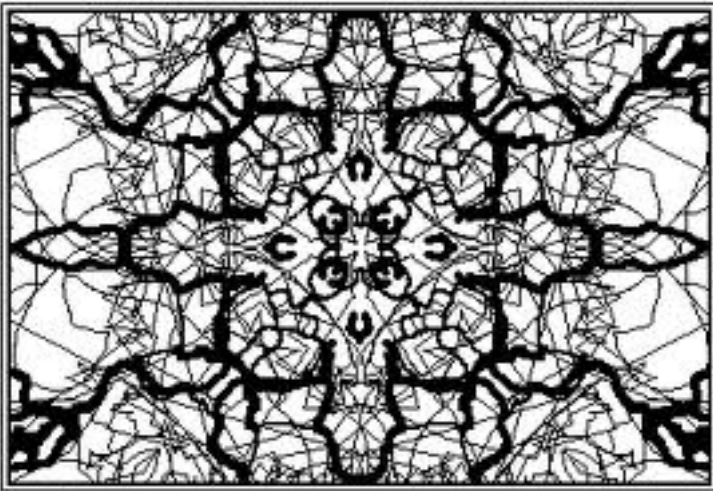
Dev Cost



Or maybe not...

Coleman, R. L., Sommerville, J. R., & Dameron, M. E. (2003). The relationship between cost and schedule growth. *Acquisition Review Quarterly*, Spring 2003, 116-123.)

Why Longer Programs May Cost More



Long programs may
be more complex

Requirements changes
responding to threat or technology
evolution



Funding Instability



Cost Impacts of Schedule Delays



“Marching Army” effect

Compound effects
of Optimism



Attitudes toward Schedules

- Schedules can be “compressed” through “hard work” and “management attention”
- Immediate resource issues can be solved by “stretching” the schedule
- Increased concurrency or doing things in parallel helps keep the program “on schedule”

Inconsistent Attitudes toward Schedules - Survey

- 96% believed integrated, up-to-date schedule is critical
- 2/3 say they have confidence in the accuracy of their master schedules
- 56% believe schedules realistic and achievable, but 40% report programs behind schedule
- 20% would slip schedule to manage cost overruns, but PMs assign highest priority to ensuring quality and performance

Yet...

- < 50% believe schedules are resource-loaded
- Only 1/2 believe schedules are complete & accurate
- Only 10% agreed that maintaining detailed schedule is too labor intensive/costly for value, but PMs reported difficulty in synchronizing schedules among players

Future Research

- Linkage between schedule and cost
 - Validation of relationship
 - Study of the cost of schedule delays
- Examination of how schedules are built and used
 - Realism of schedules built around artificial end-dates
 - Contribution of concurrency and optimism to schedule-related cost